

22 June 1959

Dear Don

This is a three subject catchall:

1 - Window and Environmental Control

Ref: Phonecon DRK-LHS/MDR 4 June 1959
Letter PFY-580-P 8 June 1959

Since it may be some time until a specific system is finally selected, the general problem is considered in as much detail as is presently possible.

The Problem

There are three important facts: (1) The outside surface of the window will be at a very high temperature, about 750°F; (2) the photographic emulsion cannot be heated above 100°F without a serious increase in its fog level (in fact, a film manufacturer has stated that the performance degradation above 100°F is so rapid that the emulsion is essentially worthless at 140°F); and (3) the high resolution required, [REDACTED] cannot be obtained if there is much turbulence in the optical path. (Unfortunately, there is no method to quantitatively specify allowable turbulence.)

STATINTL

The fundamental problem arises as a consequence of the contradictory nature of the resolution requirement and the thermal gradient -- that is, the large thermal gradient which exists must be distributed in such a way that image deterioration is minimal.

Objective

The desired objective of our window program is to develop a suitable window configuration from the overall system's point of view. The approach through which we are proceeding places initial emphasis upon optical, as opposed to thermal or structural, considerations.

Analysis

In the region from the window to the film, there are only glassy elements and air spaces. Since the image forming optics should be isothermal, the thermal gradient should be confined below the optical system -- otherwise there will have to be two controlled temperature regions (one for the film and one for the optics). Therefore the gradient must be confined to the window region. The glassy elements of the window cannot tolerate a large gradient (we cannot be quantitative yet) due to mechanical stresses and/or variation of

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the refractive index. Consequently it is desirable for the airspaces in the window configuration to carry the temperature gradient.

Our initial thinking suggests that a multilayer window with heat reflecting coatings is the only configuration consistent with the optical requirements. Whether this configuration has adequate thermal resistance without airflow between layers is still unknown. The data you have collected conclusively demonstrates the ability of confined airflow to increase the thermal resistance, but it is still uncertain what kind of inter layer airflow is tolerable optically.

In regard to airflow in the equipment bay itself, this is undesirable both optically and mechanically (it acts to unstabilize the camera), and should be avoided.

Program Outline

Our present work program concerns itself primarily with the following aspects:

1. An experimental investigation of the optical effects of airflow and heating.
2. Selection of a suitable window material.
3. Selection of a suitable heat reflecting coating.
4. Determination of optimum location(s) of coating.
5. Dimensions of window(s).

Available Detail

Answers to your questions:

- (a) Mechanically, $q = \frac{\rho v^2}{2g}$ is tolerable if it is less than 0.25 lb/ft² (order of magnitude). Optically, no airflow is desirable.
- (b) Average wattage is 400, peak wattage is 700, approximately.
- (c) No answer possible, yet.
- (d) 100°F, due to emulsion and turbulence.
- (e) Unknown presently.

Enclosed herewith are curves on best known coating. Whether this coating behaves well at elevated temperatures is not yet known.

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Questions

1. What is the temperature profile (temperature versus time) to which the outside surface of the window is subjected, from take-off to maximum temperature? The rate of change of temperature may influence selection of window material, and the duration at elevated temperatures will influence equipment design.

2. Can you comment briefly on your understanding of the physical mechanism by which heat transfer to the first window is accomplished? What emissivity figure was used for fused silica to determine 750°F? What is the temperature and emissivity of the skin adjacent to the window? The attached curve of quartz's emissivity as a function of temperature is somewhat different from the curve you showed me previously.

2 - Vehicle Drift

Ref: Our TWX 071 dated 26 May 1959
Can you give us an estimate of vehicle drift?

3 - Altitude Profile

Ref: Meeting 27 April 1959

An altitude versus time profile is desired for the operational portion of the mission. Can you provide this?

Best regards

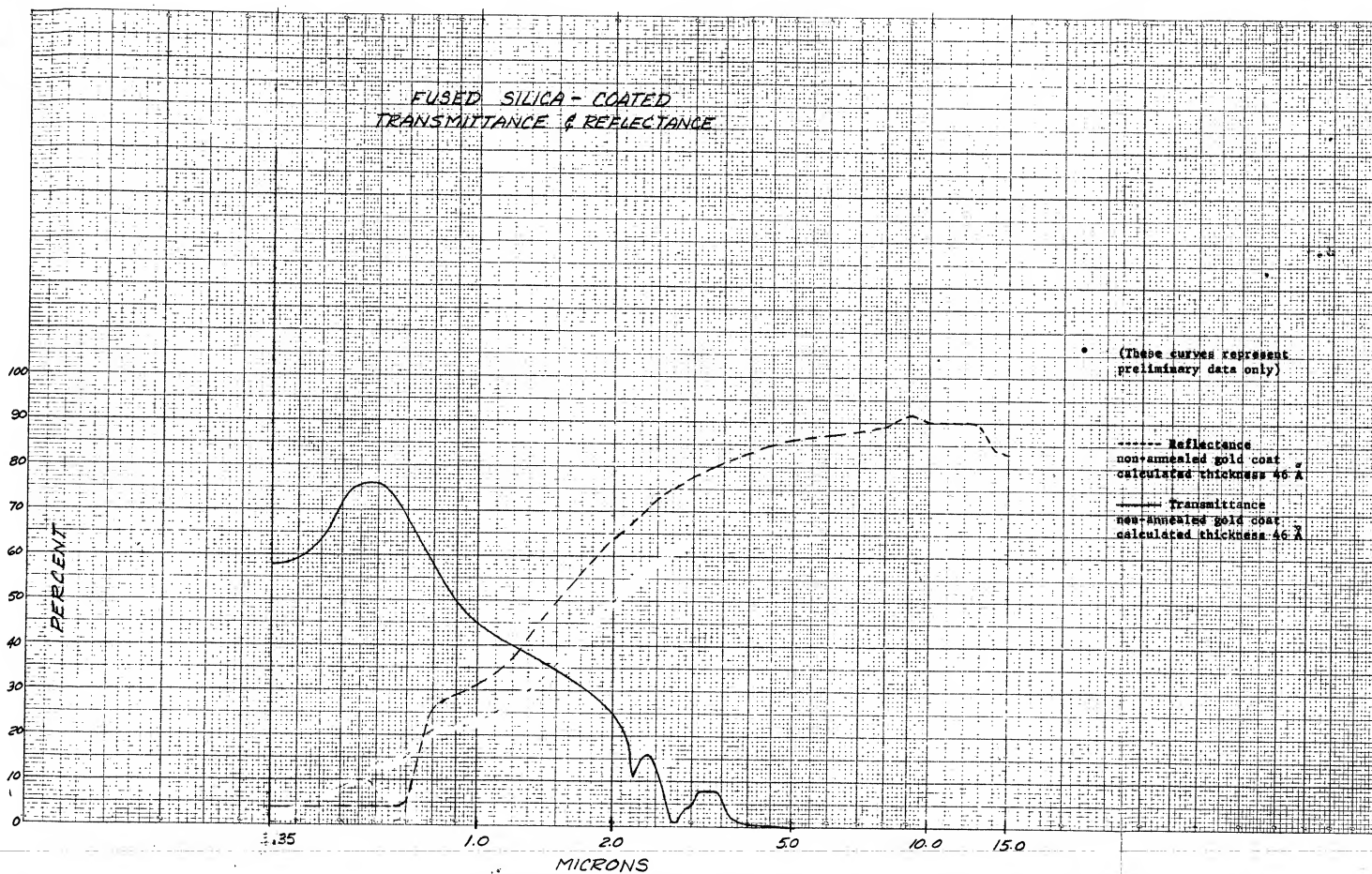
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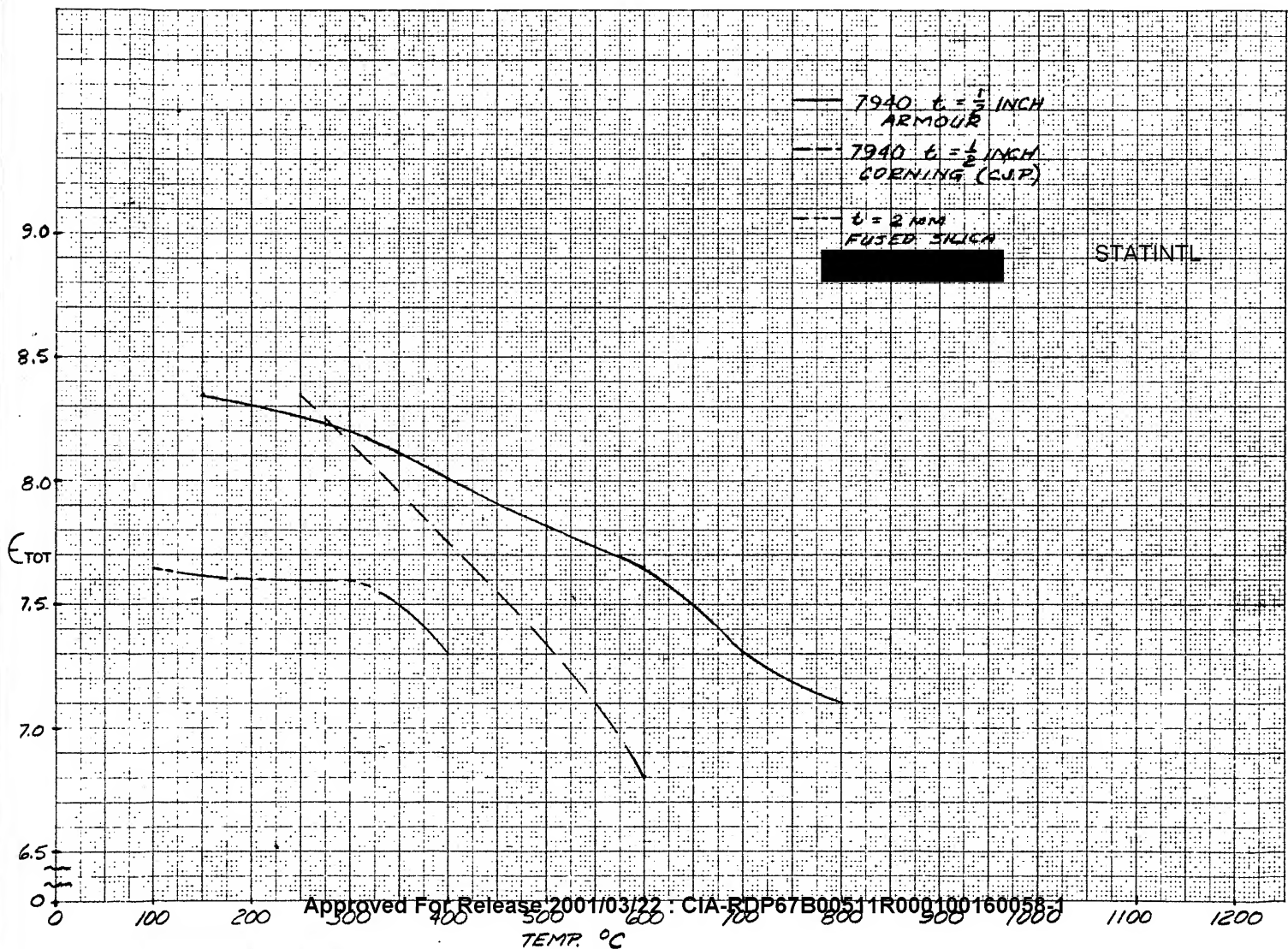
encl: Spectral Curve of Gold Coat
Quartz emissivity
Calculation of allowed dynamic pressure
Photostat of PFY-580-P

FUSED SILICA - COATED
TRANSMITTANCE & REFLECTANCE



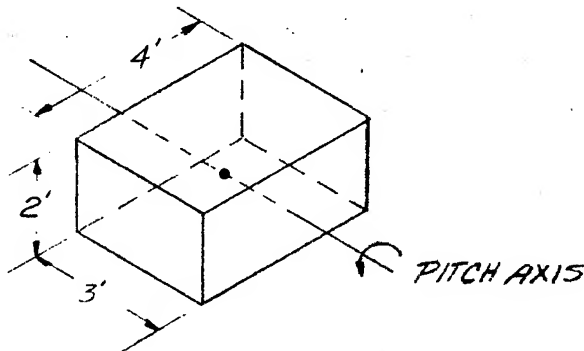


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MECHANICAL STABILITY IN AIRFLOW

ESTIMATE OF MOMENT OF INERTIA



$$\begin{aligned} I_{\text{PITCH}} &= \frac{1}{12} M (2^2 + 4^2) \\ &= \frac{500}{32} \frac{20}{12} \\ &= 26 \text{ FT.-LBS.-SEC.}^2 \end{aligned}$$

ESTIMATE OF ALLOWED TORQUE

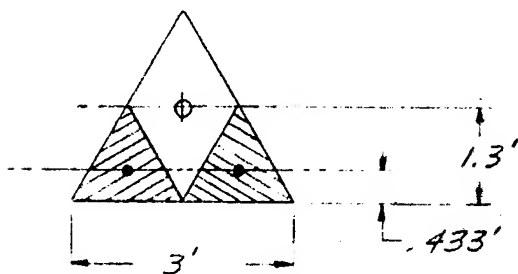
PROBABLE STABILIZER CAPABILITY

$$T_{\text{MAX.}} = I \ddot{\theta}_{\text{MAX.}} = 26 \times 1 = 26 \text{ FT.-LBS.}$$

($\ddot{\theta}_{\text{MAX.}}$ FROM PG. 30, ENGR. REPT. 5394)

$$T_a = \text{ALLOWED TORQUE FOR DRAG UNBALANCE} \approx \frac{1}{10} \text{ MAX. } T$$

ESTIMATE OF DRAG TORQUE



$$A = \text{SHADED AREA} = 2 \times \frac{1}{2} \times 1.5 \times 1.3 \approx 2 \text{ FT.}^2$$

$$\begin{aligned} T_a &= FL \\ &= (qA) \cdot (1.3 - .433) \\ &= 1.73 q \end{aligned}$$

ALLOWED DYNAMIC PRESSURE

$$q = \frac{\rho V^2}{2} = \frac{T_a}{1.73} = \frac{\frac{1}{10} T_{\text{MAX.}}}{1.73} = \frac{26}{17.3} \approx 1.5 \text{ LB.-FT.}^{-2}$$

A SIMILAR ANALYSIS FOR ROLL YIELDS
A LIMIT OF .25 LBS.-FT.⁻²

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PFY-580-P
June 8, 1959

STATINTL

To:

From:

Subject: Environmental Control Requirements

Enclosure: (A) Window Heat Transfer Analysis - Preliminary

1. Enclosure (A) presents some preliminary calculations we have made on the heat transfer through the glass area. Further work and refinement of the analysis will be required; however, the results obtained thus far are fairly enlightening.

2. We need the following information from you in order to continue our design and would appreciate receipt of these data as soon as possible, for the configuration selected from the various ones you are considering.

(a) Maximum allowable $q (= \frac{P}{A})$ in the space housing the equipment which is sensitive to drag forces resulting from airflow.

(b) Peak and average wattage to the equipment in space discussed in (a) above. 700 Watts Av. 700 Watts peak

(c) Is forced cooling required for any of the electronic packages? If so, how much? UNKNOWN.

(d) What is the maximum allowable inner surface temperature of the inner glass?

(e) What is the limit on window temperature gradients?

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DRK:LHS:fh

cc:

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